

S P E C I F I C A T I O N

Docket No. **SILA0006**

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT I, **Scott Allan Woodford**, a citizen of the United States of America, residing in the State of Texas, have invented new and useful improvements in an

APPARATUS FOR CONTROLLING MODULATION OF AN ALTERNATING WAVEFORM ON A DC VOLTAGE SIGNAL WITHIN A LOW-NOISE BLOCK CONTROLLER

of which the following is a specification:

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to signal modulations in general, and in particular to an apparatus for controlling signal modulations. Still more particularly, the present invention relates to an apparatus for controlling modulation of an alternating waveform on a direct current voltage signal within a low-noise block controller.

2. Description of Related Art

A digital satellite communication system typically employs a ground-based transmitter that beams an uplink signal to a satellite positioned in a geosynchronous orbit. In turn, the satellite relays the signal back to various ground-based receivers. Such digital satellite communication system permits a household (or business) subscribing a satellite television service to receive audio and video signals directly from the satellite by means of a directional receiver antenna that is typically affixed to the roof or an external wall of the subscriber's residence.

A directional receiver antenna constructed to receive satellite signals typically includes a dish-shaped reflector that has a feed support arm protruding outward from the front surface of the reflector. The feed support arm supports an assembly in the form of a low-noise block (LNB) amplifier having an integrated LNB feed. The reflector collects and focuses satellite signals onto the LNB feed.

The satellite signals are commonly received at the Ku-band or C-band. The received satellite signals are first amplified and then downshifted to a predetermined frequency band, typically in the L-band. The satellite signals are then sent via a coaxial cable to a set-top box typically located adjacent to a subscriber's television.

1 The components within a set-top box can be divided into two major sections,
2 namely, an LNB control section and a signal processing section. The signal processing
3 section is beyond the scope of the present disclosure. The LNB control section controls
4 the functionality of an LNB amplifier located on the feed support arm of a directional
5 receiver antenna.

6
7 Generally speaking, the LNB control section includes, *inter alia*, a direct
8 current (DC) power supply, a summing circuit, a switch and an LNB control device. The
9 DC power supply, the summing circuit and the switch are discrete components external to
10 the LNB control device. The LNB control device typically generates various control
11 signals for controlling the DC power supply, the summing circuit, and the switch. For
12 example, the LNB control device provides an alternating waveform to be added to a DC
13 voltage signal originated from the DC power supply, and the waveform modulation is
14 performed within the summing circuit. In addition, the LNB control device provides a
15 switch control signal to control the switch that allows the modulated DC voltage signal to
16 pass to an LNB amplifier.

17
18 The present disclosure provides an improved apparatus for controlling the
19 modulation of an alternating waveform on a DC voltage signal within a LNB controller.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, an apparatus for controlling modulation of an alternating waveform on a direct current (DC) signal within a low-noise block (LNB) controller includes a DC power supply and a mixing/switching circuit. The DC power supply provides a steady DC voltage to a load, such as an LNB amplifier. The mixing/switching circuit adds a modulating signal to the DC voltage and selectively allows the modulated DC voltage to the load. The mixing/switching circuit includes a common control signal input for managing both of the above-mentioned two functions.

All objects, features, and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention itself, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 is a conceptual block diagram of an apparatus for controlling modulation of an alternating waveform on a direct current (DC) voltage signal within a low-noise block (LNB) controller;

Figure 2 is a functional block diagram of an apparatus for controlling modulation of an alternating waveform on a DC voltage signal within an LNB controller, in accordance with a preferred embodiment of the present invention;

Figure 3 is a circuit diagram of the apparatus from Figure 2, in accordance with a preferred embodiment of the present invention;

Figure 4 is a graphical illustration of the range for a control signal for the apparatus from Figure 2, in accordance with a preferred embodiment of the present invention; and

Figure 5 is a simplified block diagram of an LNB controller within a satellite video receiver for controlling an LNB amplifier on a satellite dish, in which a preferred embodiment of the present invention is incorporated.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

With reference now to the drawings and in particular to Figure 1, there is illustrated a conceptual block diagram of an apparatus for controlling modulation of an alternating waveform on a direct current (DC) voltage signal within a low-noise block (LNB) controller, in accordance with a preferred embodiment of the present invention. As shown, an apparatus **10** includes a DC power supply **11**, a summing circuit **12** and a switch **13**. An alternating waveform is added to a DC voltage originated from DC power supply **11** via an input **15** within summing circuit **12** to produce a modulated DC voltage. The modulated DC voltage is intended for a load **14** such as an LNB amplifier. The modulated DC voltage can be disconnected from load **14** via a switch control signal at an input **16** within switch **13**. The alternating waveform to input **15** and the switch control signal to input **16** are preferably provided by an LNB control device (not shown).

It is clear that an implementation of the conceptual block diagram as shown in Figure 1 requires two signal inputs, *i.e.*, inputs **15** and **16**. Accordingly, two signal input pins are required for the LNB control device in order to provide the required signal controls as shown in Figure 1. As packages for integrated circuits become increasingly smaller, it is important to reduce the number of pins on an integrated circuit device, such the LNB control device, if it is at all possible.

With reference now to Figure 2, there is depicted a functional block diagram of an apparatus for controlling modulation of an alternating waveform on a DC voltage signal within an LNB controller, in accordance with a preferred embodiment of the present invention. As shown, an apparatus **20** includes a DC power supply **21** and a mixing/switching circuit **22**. DC power supply **21** outputs a steady DC voltage. Mixing/switching circuit **22** is configured to add a modulating signal to the DC voltage from DC power supply **21**. In addition, mixing/switching circuit **22** can selectively allow the modulated DC voltage to reach a load **24** such as an LNB amplifier. Instead of having two separate

1 control signal inputs (as shown in Figure 1), a single signal input **25** is utilized to supply
2 a modulating/switch signal for the control of the above-mentioned two functions of
3 mixing/switching circuit **22**. The modulating/switch signal is preferably provided by an
4 LNB control device (not shown) located apart from apparatus **20**.

5
6 Referring now to Figure 3, there is illustrated a circuit diagram of apparatus
7 **20** from Figure 2, in accordance with a preferred embodiment of the present invention. As
8 shown, apparatus **20** includes a capacitor **C**, two diodes **D1-D2**, three resistors **R1-R3** and
9 three transistors **Q1-Q3**. The emitter of transistor **Q1** is connected to the positive terminal
10 of power supply **21**. The emitter of transistor **Q1** is also connected to the base of transistor
11 **Q3** via resistor **R1**. The base of transistor **Q1** is connected to the collector of transistor **Q2**
12 via resistor **R3**. The collector of transistor **Q1** is connected to the collector of transistor
13 **Q3**. The base of transistor **Q2** is connected to signal input **25** via diodes **D1-D2** connected
14 in series. Specifically, the anode of diode **D1** is connected to the anode of diode **D2**, and
15 a 3.3 V power supply is connected to the anodes of diodes **D1-D2** via resistor **R2**. The
16 emitter of transistor **Q2** is connected to ground. The base of transistor **Q3** is also
17 connected to signal input **25** via capacitor **C**. The emitter of transistor **Q3** provides a
18 modulated DC voltage to a load, such as load **24**.

19
20 Transistor **Q3**, resistor **R1** and capacitor **C** together provide the modulation
21 of an alternating waveform from signal input **25** to a DC voltage from DC supply **21**.
22 Also, transistors **Q1-Q2**, resistors **R2-R3** and diodes **D1-D2** perform the switching function.

23
24 Preferably, transistor **Q1** is a PNP transistor, transistor **Q2** is an NPN
25 transistor and transistor **Q3** is an NPN Darlington transistor. Also, the resistances of
26 resistor **R1**, resistor **R2** and resistor **R3** are 2.2 k Ω , 33 k Ω and 2.2 k Ω , respectively. The
27 capacitance of capacitor **C** is 100 nF.

1 As mentioned above, signal input 25 adds an alternating waveform to a DC
2 voltage and selectively allows the modulated DC voltage to reach load 24. This is
3 accomplished by dividing the total voltage operating range of apparatus 20 into two modes,
4 namely, a modulation mode and a disconnect mode. During the modulation mode, an
5 alternating waveform is added to the DC voltage from DC power supply 21 and the
6 modulated DC voltage is allowed to reach load 24. During the disconnect mode, the DC
7 voltage is not modulated and is prevented from reaching load 24.

8 9 I. Modulation mode

10 Apparatus 20 can be maintained in the modulation mode by keeping signal
11 input 25 above 0.9 V to keep diode D1 off. As such, current is permitted to be supplied
12 through resistor R2 and diode D2 to the base of transistor Q2, allowing transistor Q2 to
13 carry enough collector current to maintain transistor Q1 in, or close to, saturation. Such
14 is necessary to provide enough current to the load to maintain the desired load voltage.

15
16 Resistor $R1 \gg 1/(2 \pi f C) = X_c$, where f is the frequency of an alternating
17 waveform, and X_c is the capacitive reactance of capacitor C at frequency f . This decouples
18 the base of transistor Q3 from the collector of transistor Q3 at frequency f of the
19 alternating waveform, allowing the alternating waveform at signal input 25 to couple across
20 capacitor C to the base of transistor Q3. Transistor Q3 then modulates the alternating
21 waveform at the base of transistor Q3 onto the DC voltage from DC power supply 21 in
22 an emitter-follower manner. The frequency f of the alternating waveform is preferably 22
23 kHz.

24 25 II. Disconnect mode

26 The disconnect mode occurs when signal input 25 is pulled low (*i.e.*, less
27 than 0.6 V but preferably 0 V). This causes diode D1 to turn on, diverting the current
28 supplied through resistor R2 to signal input 25. Since this current is no longer supplied to
29 the base of transistor Q2, transistor Q2 is turned off, stopping the collector of transistor Q2

1 from sinking current from the base of transistor Q1. In turn, transistor Q1 is stopped from
2 supplying current through its collector to load 24, disconnecting the DC power supply 21
3 from load 24.

4
5 With reference now to Figure 4, there is depicted a graphical illustration of
6 the entire voltage operating range for a modulating/switch control signal at signal input 25,
7 in accordance with a preferred embodiment of the present invention. As shown, V_{\min} is
8 preferably 0 V, and V_{\max} is preferably 3.3 V. DC power supply 21 is disconnected from
9 load 24 when signal input 25 is below approximately 0.6 V. DC power supply 21 is
10 connected to load 24 when signal input 25 is above approximately 0.9 V. Modulation
11 occurs when signal input 25 is approximately between 0.9 V and 3.3 V. The voltage range
12 of the alternating waveform on the DC voltage is preferably between 2.2 V and 3.0 V.

13
14 As an example, if the range of the voltage to signal input 25 (V_p) is between
15 0 V and 3.3 V, and it is desirable to modulate a ± 0.4 V signal onto the DC voltage from
16 DC power supply 21, apparatus 20 can be operated under the modulation mode with $V_p =$
17 $2.6 \text{ V} \pm 0.4 \text{ V}$, and under the disconnect mode with $V_p = 0 \text{ V}$.

18
19 Referring now to Figure 5, there is depicted a simplified block diagram of
20 an LNB controller within a satellite video receiver for controlling an LNB amplifier on a
21 satellite dish, in which a preferred embodiment of the present invention is incorporated.
22 As shown, an LNB controller 50 includes a DC power supply 51, a mixing/switching
23 circuit 52 and an LNB control device 53. DC power supply 51 outputs a DC voltage signal
24 to mixing/switching circuit 52. An alternating waveform is then added to the DC voltage
25 signal via a signal input 58 from LNB control device 53. LNB control device 53 controls
26 DC power supply 51 via a power supply control line 57. In turn, DC power supply 51
27 provides a feedback to LNB control device 53 via a feedback line 58. In addition, LNB
28 control device 53 receives a feedback from LNB amplifier 56 via a feedback line 56.

1 As has been described, the present invention provides an improved apparatus
2 for controlling the modulation of an alternating waveform on a DC signal within an LNB
3 controller.
4

5 While the invention has been particularly shown and described with reference
6 to a preferred embodiment, it will be understood by those skilled in the art that various
7 changes in form and detail may be made therein without departing from the spirit and scope
8 of the invention.